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(54) **WORK VEHICLE WITH IMPROVED EXHAUST COMPONENT COOLING**

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F01N 13/14 (2010.01)
B60K 11/06 (2006.01)

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(57) **ABSTRACT**

(52) **U.S. Cl.**

CPC **B60K 13/04** (2013.01); **B60K 11/06** (2013.01); **F01N 3/021** (2013.01); **F01N 3/055** (2013.01); **F01N 13/143** (2013.01); **F01N 13/1805** (2013.01); **F01N 2260/022** (2013.01)

A work vehicle in which a cooling fan is arranged forward of an engine and an exhaust gas purification device is arranged rearward of the engine. An inlet-side exhaust passage connects an exhaust manifold and the exhaust gas purification device. An outlet-side exhaust passage connects the exhaust gas purification device and the exhaust end portion. A first exhaust passage is coupled to the exhaust gas purification device and passes over the exhaust gas purification device to reach beside a first end portion. A second exhaust passage is coupled to the first exhaust passage and extends in a transverse direction and below the exhaust gas purification device.

(58) **Field of Classification Search**

CPC B60K 13/00–13/04; B60K 11/06
See application file for complete search history.

20 Claims, 10 Drawing Sheets

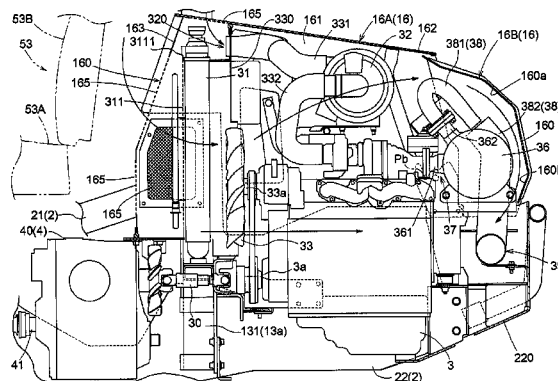


Fig. 1

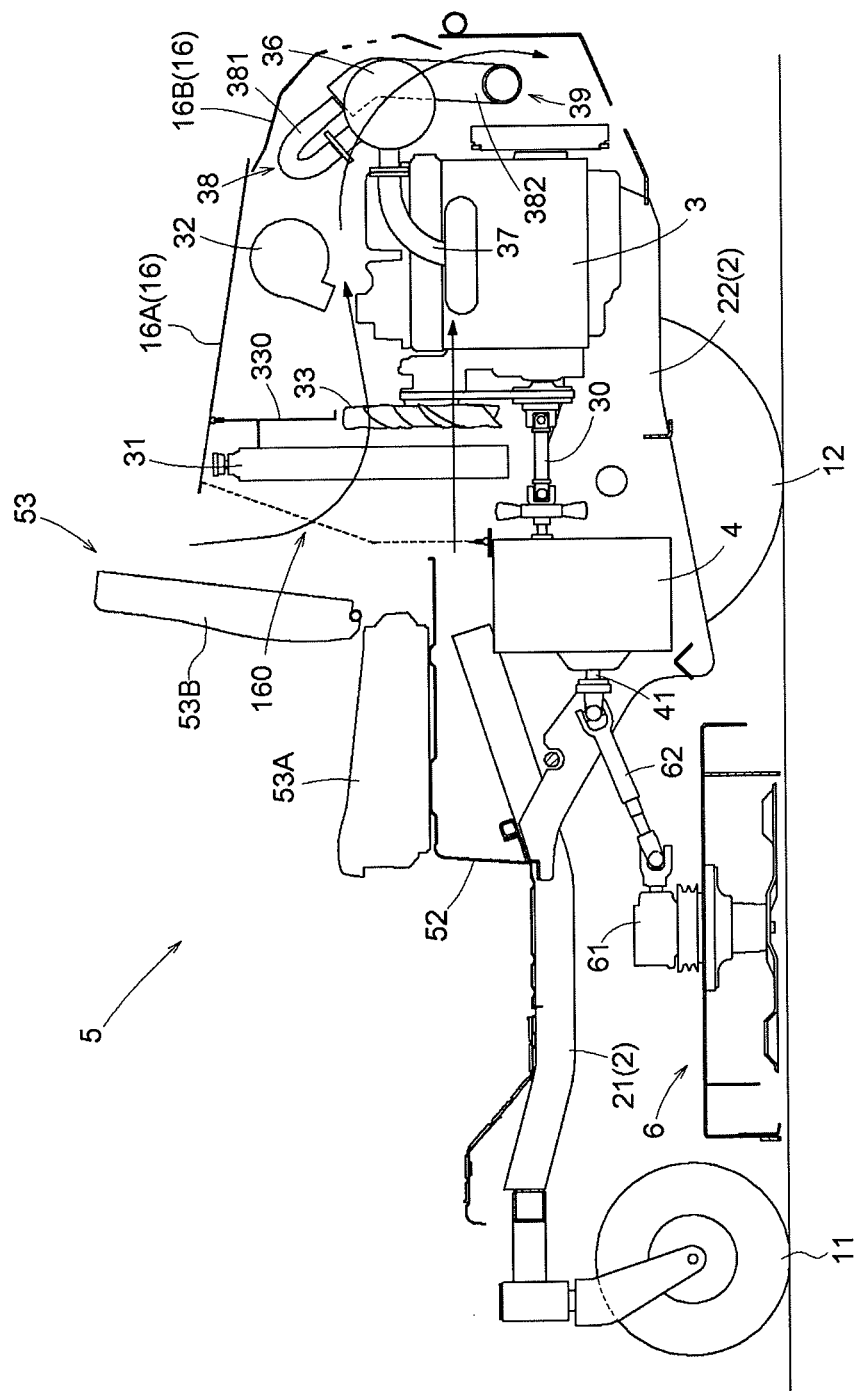
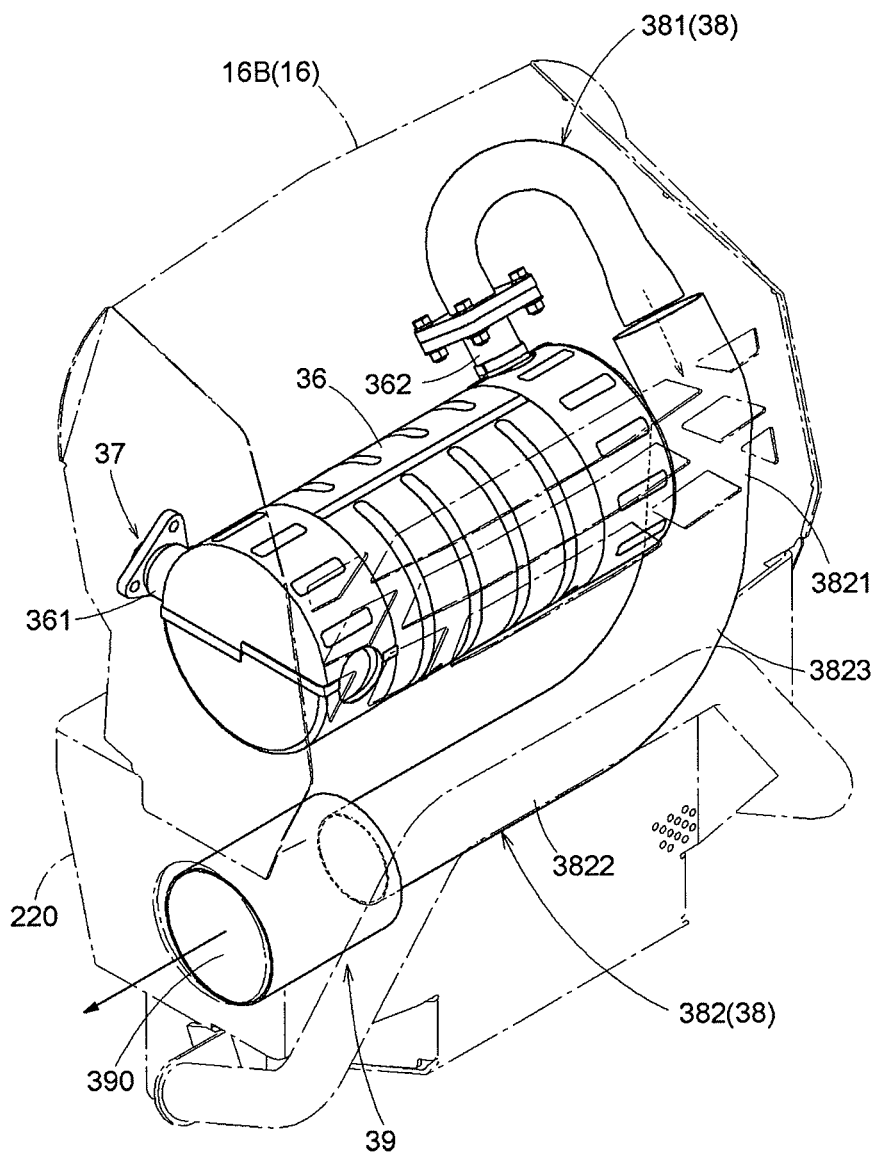


Fig. 2



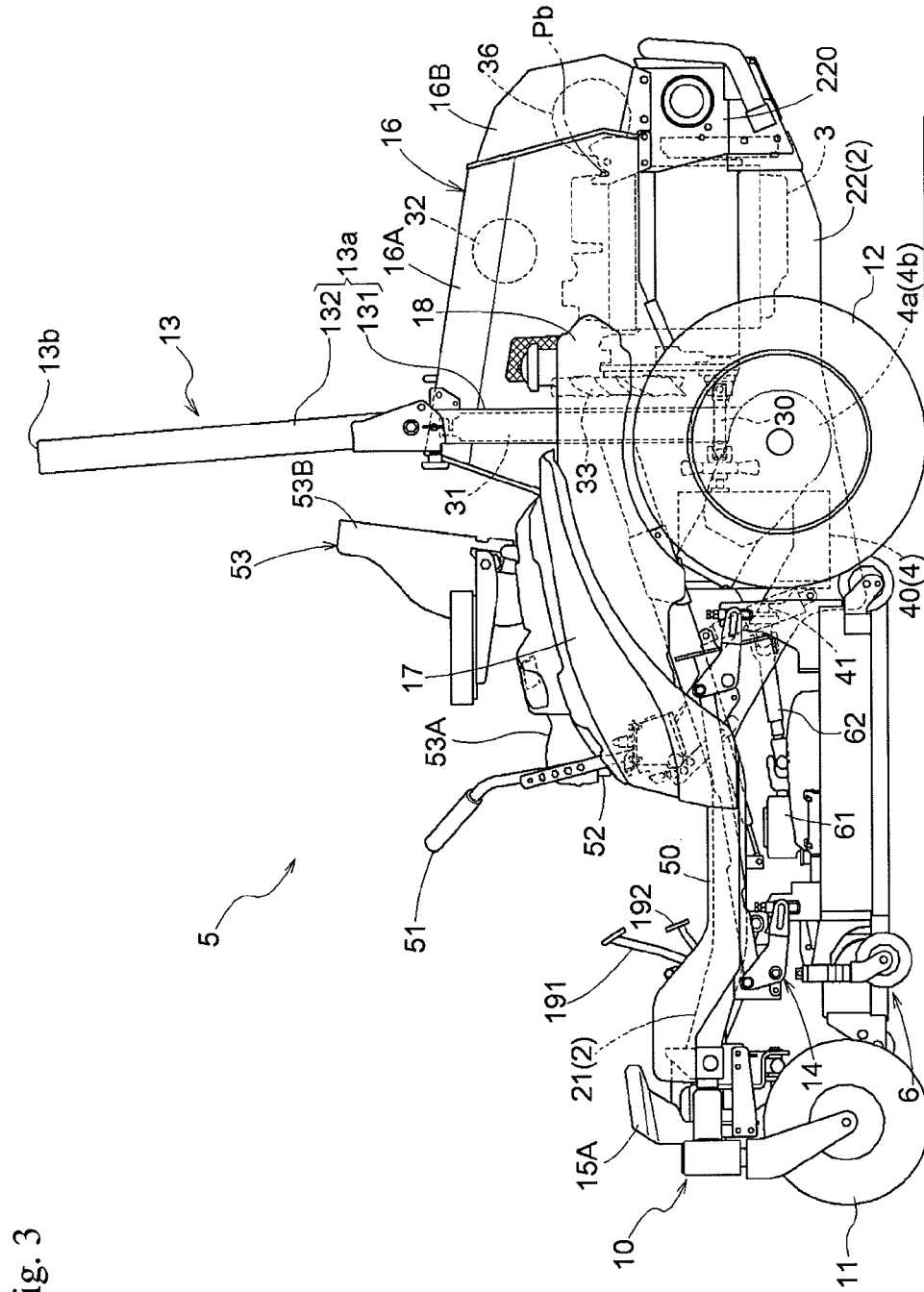


Fig. 3

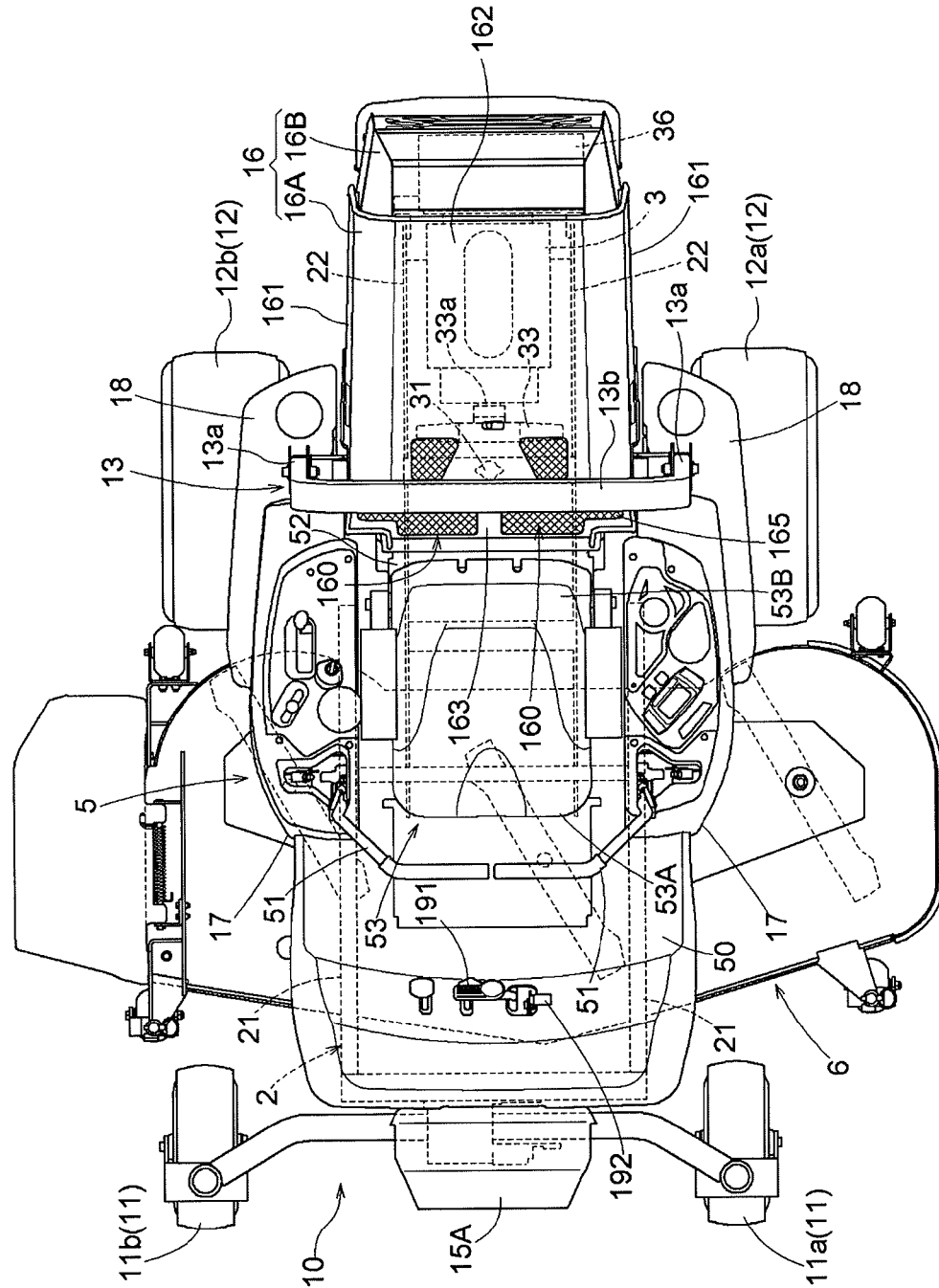
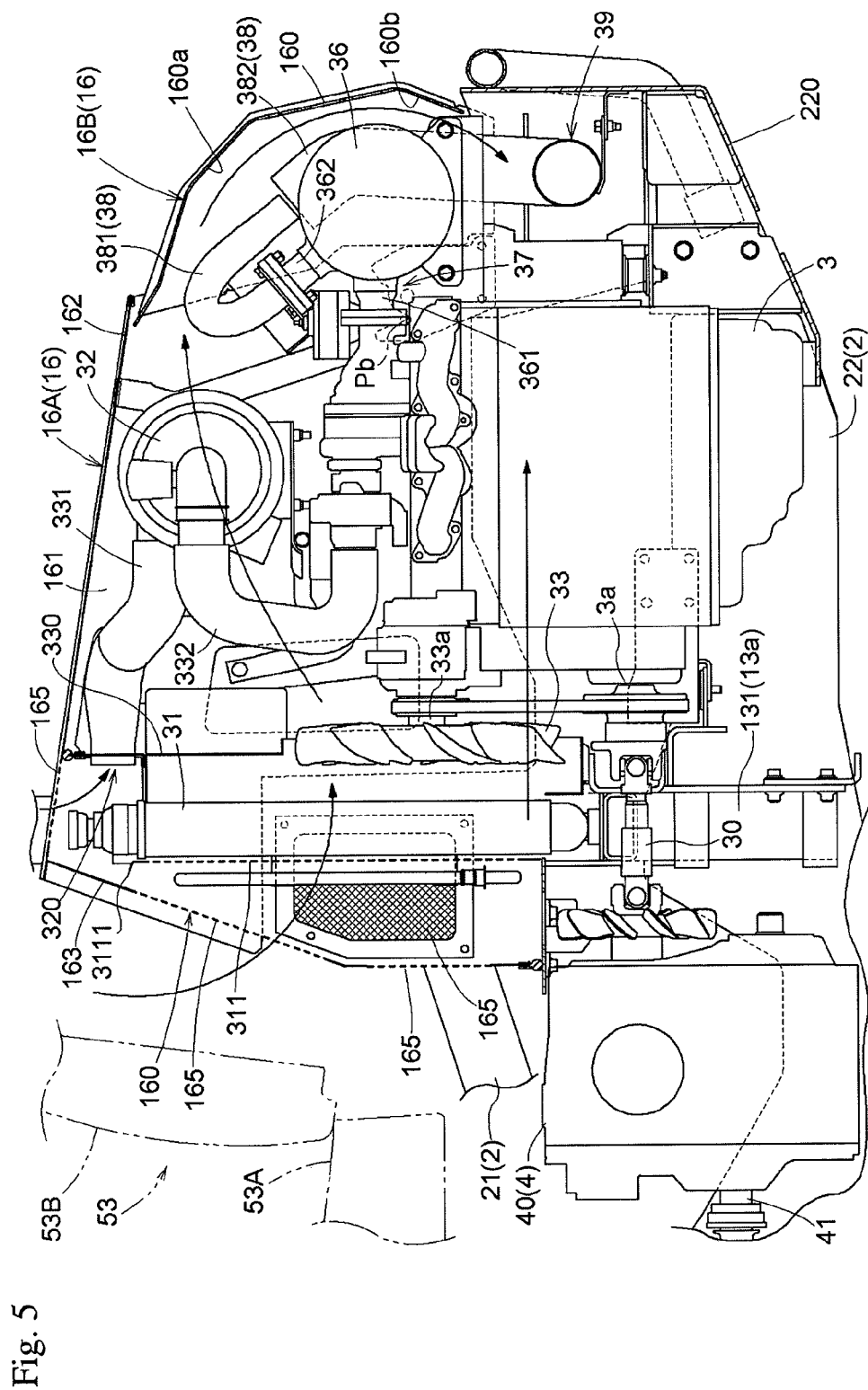


Fig. 4



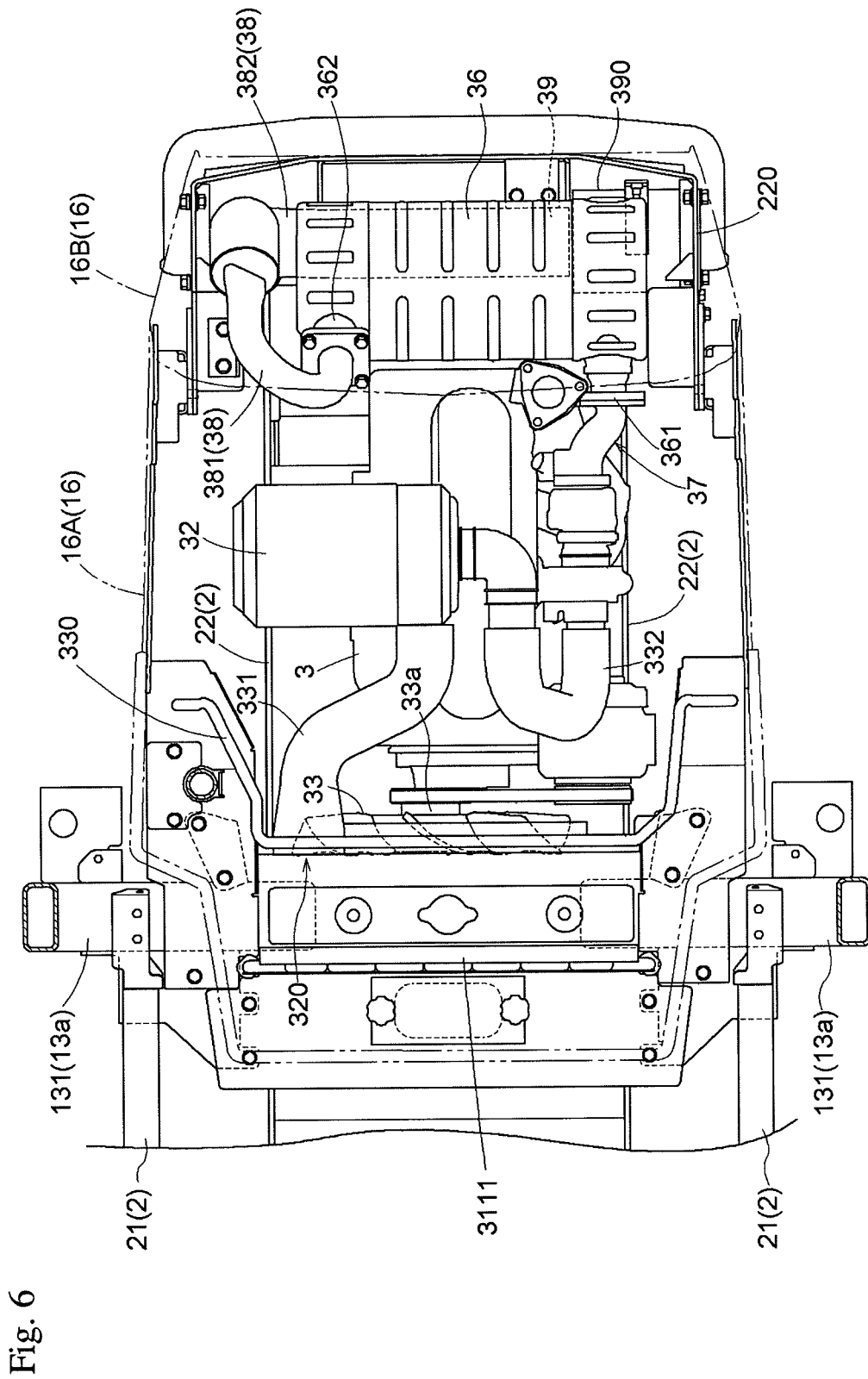


Fig. 7

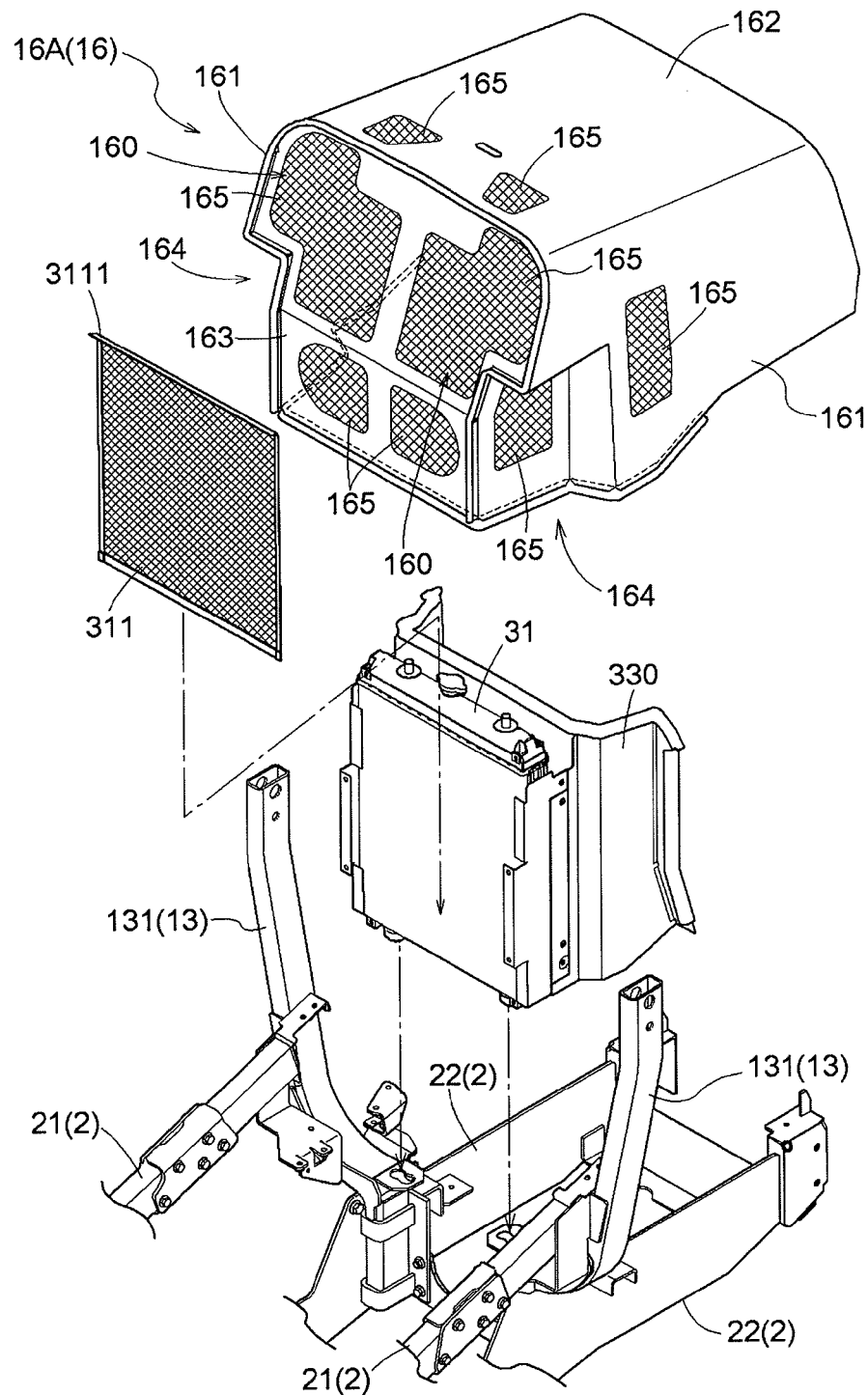


Fig. 8

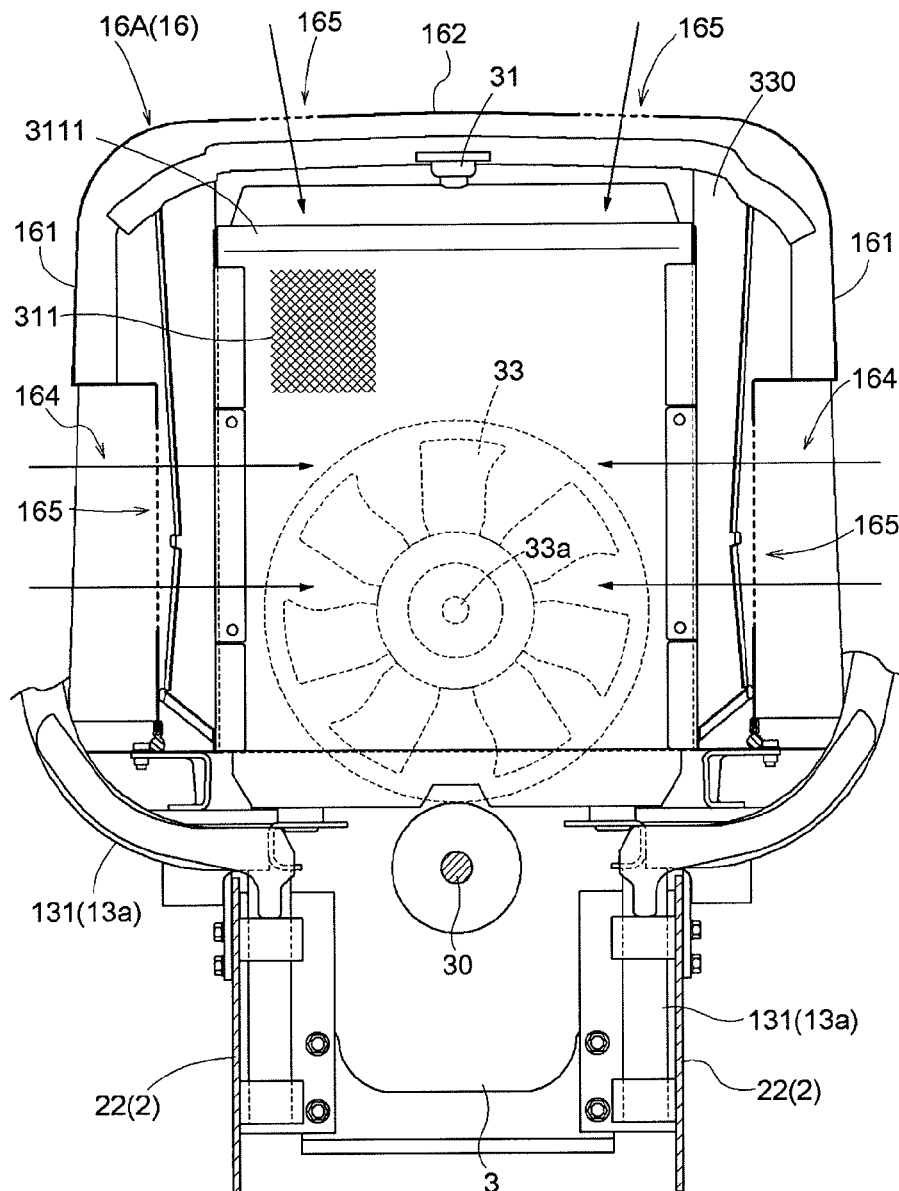


Fig. 9

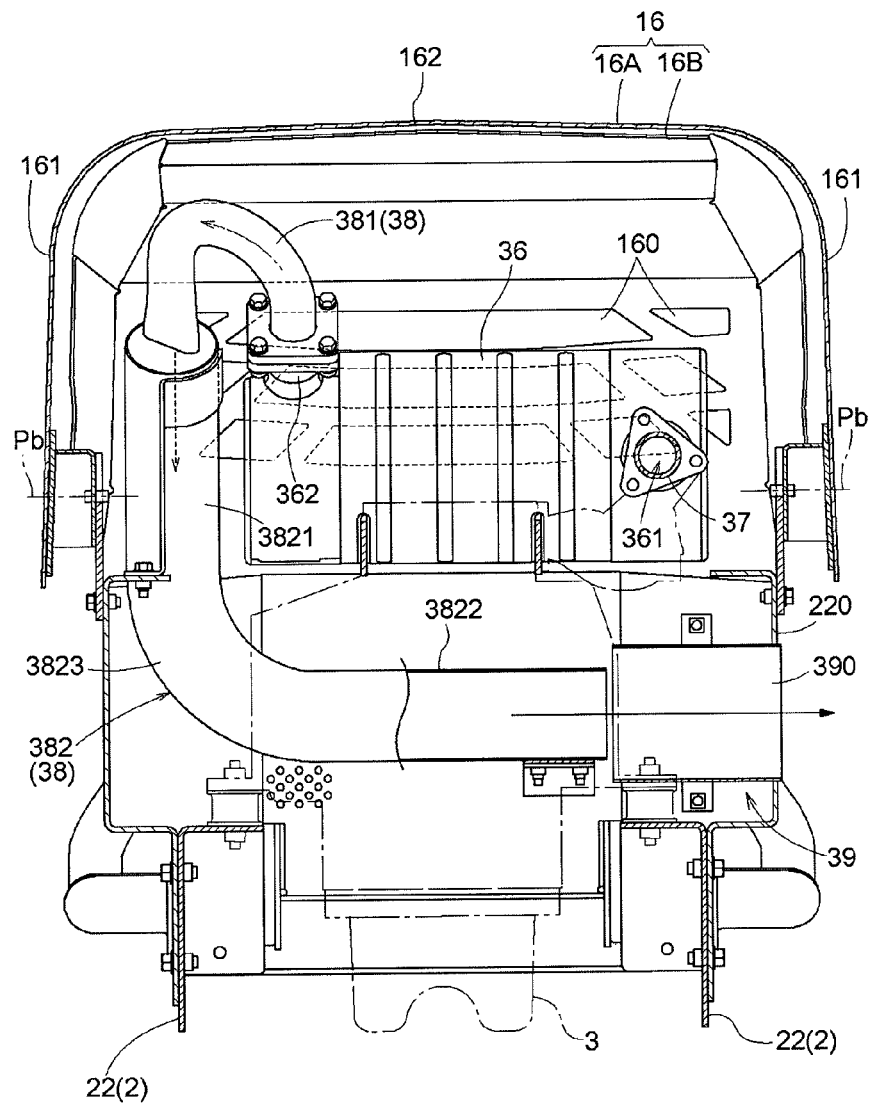
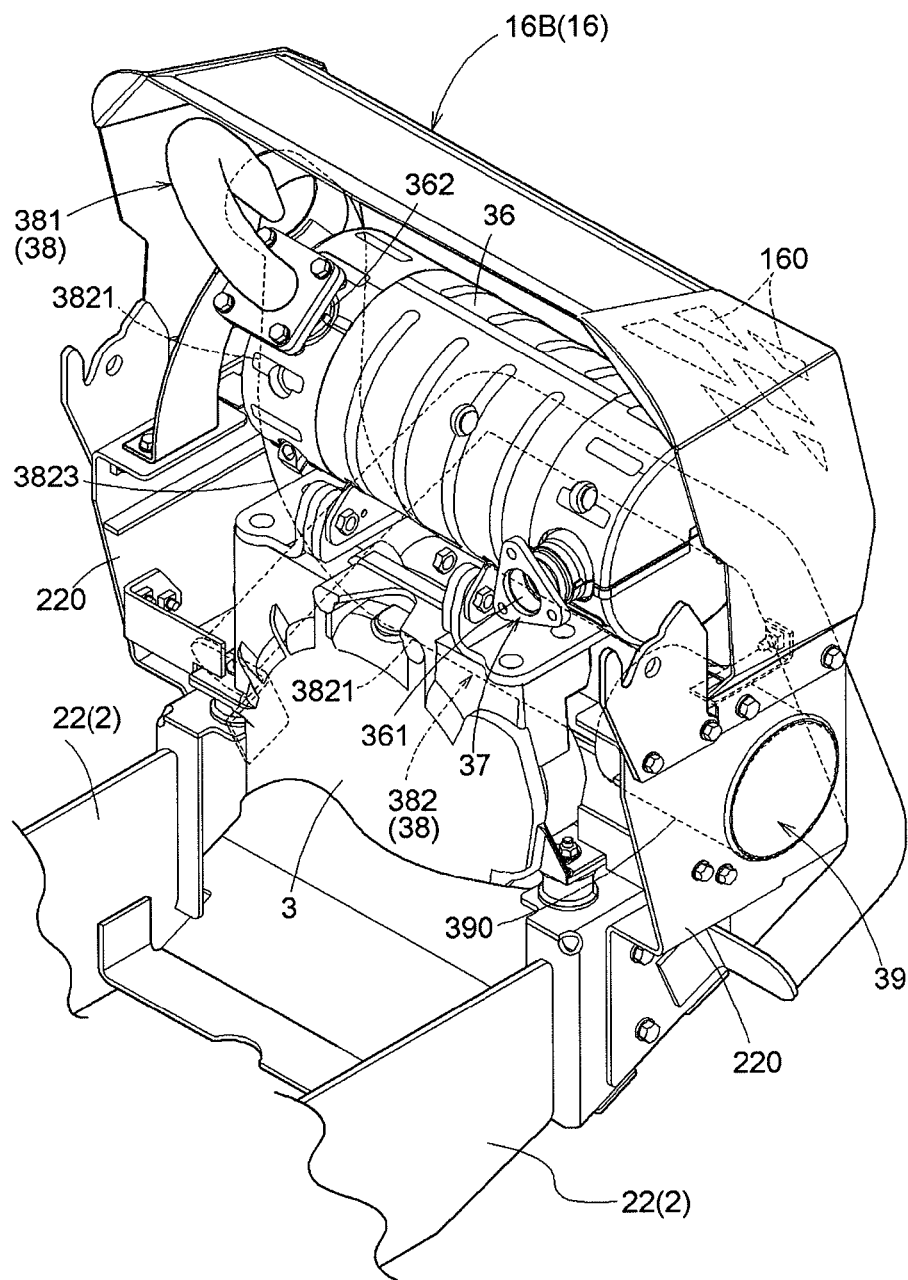


Fig. 10



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WORK VEHICLE WITH IMPROVED EXHAUST COMPONENT COOLING

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. §119 of Japanese Application No. 2015-000360, filed on Jan. 5, 2015, the disclosure of which is expressly incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a work vehicle having a diesel engine installed in a rear portion of a vehicle frame. The vehicle has a system that improves exhaust component cooling.

2. Description of Related Art

In order to improve and resolve the environmental concerns of recent years, exhaust gas regulations have been toughened for diesel engines and the like. In work vehicles such as construction or agricultural machinery, various technologies have been developed which reduce particulate matter contained in exhaust gas so as to comply with such exhaust gas regulations. For example, instead of a conventional muffler, an exhaust gas purification device collecting particulate matter contained in exhaust gas may be mounted to a work vehicle. The exhaust gas purification device passes the exhaust gas through a diesel particulate filter (hereafter referred to simply as DPF) installed therein to collect the particulate matter. The collected particulate matter accumulates gradually in the DPF of the exhaust gas purification device, and so in order to prevent the DPF from clogging and prevent an increase in air resistance of the exhaust system, the particulate matter must be burned off and the DPF renewed. Therefore, an outer surface of the exhaust gas purification device housing the DPF must be configured to avoid being excessively cooled, and an exhaust pipe must be effectively cooled so as to reduce a temperature of the exhaust gas discharged to the exterior from the exhaust gas purification device.

A work vehicle disclosed in Japanese Patent Laid-open Publication No. 2012-026326 is configured as a riding mower having a mower unit arranged below a vehicle frame between left-right pairs of front and rear wheels, a driver's seat arranged at a center portion of the vehicle frame, an engine compartment covered by a hood formed at a rear portion of the vehicle frame, and an engine and engine components arranged within the engine compartment. The engine is a diesel engine having a radiator and a cooling fan provided on a front side. A DPF (exhaust gas purification device) purifying engine exhaust gas is arranged at a position rearward and above the diesel engine, and an air cleaner is provided at a position above the diesel engine. The exhaust gas flowing in from a left front side of the DPF is discharged through a short exhaust pipe which extends horizontally further toward the rear of the vehicle from an exhaust outlet on a right rear side of the DPF and opens toward the rear of the vehicle. The shortness of the exhaust pipe discharging the final stage of the exhaust gas is a measure to prevent the vehicle body from increasing in length; however, when the exhaust pipe is insufficiently cooled, exhaust gas having a comparatively high temperature may be discharged from the exhaust outlet.

In a riding mower disclosed in Japanese Patent Laid-open Publication No. 2013-209949, which has a similar format, in

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order to ensure an adequate length for an exhaust pipe, exhaust gas exiting an exhaust gas purification device flows through an exhaust passage, which extends forward and upward from the exhaust gas purification device, after which the exhaust passage extends forward of and above the exhaust gas purification device in a transverse direction of the vehicle until it passes the diesel engine, and further extends along a side wall of the diesel engine so as to descend toward the front, after which the exhaust passage reverses course and extends rearward along the side wall of the diesel engine to terminate at an exhaust outlet. With such an exhaust pipe layout, space above the rear portion of the engine and space beside a rear half of the engine is occupied by the exhaust pipe. In particular, a flow cross-sectional area of the exhaust pipe close to the exhaust outlet is large, and therefore the required space beside the rear half of the engine is larger. As a result, a width of the hood increases.

In view of the above circumstances, an improved layout of an exhaust pipe between an exhaust gas purification device and a final stage exhaust gas exhaust mouth is desired within a narrow engine compartment.

SUMMARY OF THE INVENTION

A work vehicle according to the present invention includes: a diesel engine mounted in a rear portion of a vehicle frame; a cooling fan arranged forward of the diesel engine; an exhaust gas purification device arranged rearward of the diesel engine and provided with a filter collecting particulate matter contained in exhaust gas discharged from the diesel engine; an exhaust end portion having a discharge opening expelling the exhaust gas to a vehicle exterior; an inlet-side exhaust passage connecting an exhaust manifold of the diesel engine and an inlet of the exhaust gas purification device; an outlet-side exhaust passage connecting an outlet of the exhaust gas purification device and the exhaust end portion; a first exhaust passage configuring the outlet-side exhaust passage, the first exhaust passage being coupled to the outlet of the exhaust gas purification device and passing over the exhaust gas purification device to reach beside a first end portion of the exhaust gas purification device; and a second exhaust passage configuring the outlet-side exhaust passage, the second exhaust passage being coupled to the first exhaust passage and extending in a transverse direction of the vehicle from beside the first end portion of the exhaust gas purification device, below the exhaust gas purification device, to the exhaust end portion.

According to this configuration, the outlet-side exhaust passage, which discharges the exhaust gas exiting the exhaust gas purification device to the exterior while cooling the exhaust gas, rises above the exhaust gas purification device, then reverses course and descends beside the exhaust gas purification device to the bottom end of the exhaust gas purification device, after which the outlet-side exhaust passage extends below the exhaust gas purification device in the transverse direction of the vehicle. Accordingly, a majority of the space above the exhaust gas purification device forms a space where cooling air flows smoothly, and the outlet-side exhaust passage effectively does not occupy areas forward and rearward of the exhaust gas purification device in the front-back direction of the vehicle. In other words, a portion of the cooling air guided into the engine compartment by the cooling fan can pass smoothly above the diesel engine and behind the exhaust gas purification device to reach the outlet-side exhaust passage extending below the exhaust gas purification device in the transverse direction of the vehicle,

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and the exhaust gas flowing through the outlet-side exhaust passage can be cooled efficiently.

According to another aspect of the present invention, the first exhaust passage extends through a position higher than a top end of the diesel engine. According to this configura-
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The second exhaust passage extends beside and below the exhaust gas purification device, where there is extra space, and therefore a sufficiently large flow cross-sectional area can be readily formed. Therefore, in another aspect of the present invention, the flow cross-sectional area of the second exhaust passage is larger than the flow cross-sectional area of the first exhaust passage, and a gap in the transverse direction is formed at the connection between the first exhaust passage and the second exhaust passage such that outside air flows into the second exhaust passage together with exhaust gas from the first exhaust passage.

The exhaust passage is configured by metal pipes made by sheet metal working; therefore, the simpler the extending shape of the exhaust passage, the lower the manufacturing cost. Thus, in another aspect of the present invention, the second exhaust passage is configured by a downward portion extending downward beside the first end portion of the exhaust gas purification device; a sideways portion extending horizontally in a straight line below the exhaust gas purification device; and a two-dimensional bend portion coupling the downward portion and the sideways portion (having a center line of the bend positioned substantially on a two dimensional plane).

In another aspect of the present invention, the exhaust end portion is arranged such that the discharge opening is oriented in the transverse direction of the vehicle. According to this configuration, the terminal end of the second exhaust passage and the exhaust end portion can be arranged to be coaxial, and the exhaust end portion can be configured by a simple tube. In addition, a length of the hood can be shortened as compared to a case employing a rearward exhaust format.

In order to effectively cool the second exhaust passage, preferably, the cooling air guided into the upper space of the engine compartment by the cooling fan is smoothly deflected downward in an area near a rear wall of the engine hood to directly arrive at the second exhaust passage. Therefore, in another aspect of the present invention, the engine hood is configured by a front hood covering the cooling fan, the diesel engine, and the inlet-side exhaust passage; and a rear hood covering the exhaust gas purification device and the outlet-side exhaust passage. The rear hood is formed as a downward deflection plate such that, after cooling air from the cooling fan passes over the diesel engine, the cooling air passes behind the exhaust gas purification device to arrive below the exhaust gas purification device.

High temperatures are generated in the exhaust gas purification device while being renewed, and therefore hot air in the vicinity of the exhaust gas purification device must be pushed away. Therefore, in another aspect of the present invention, the radiator is arranged such that a height-direction center portion of the radiator, which is positioned forward of the diesel engine, is in a boundary region situated between the diesel engine and the air cleaner, which is positioned above the diesel engine. A lower half of the flow of air passing the radiator and entering the engine compartment cools a surface of the engine while directly striking the diesel engine, and an upper half of the flow of air pushes hot air rising above the diesel engine away to lower a tempera-

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ture within the engine compartment. According to this configuration, cooling of the diesel engine itself, as well as outflow of hot air above the engine and in the vicinity of the exhaust gas purification device, is achieved efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described in the detailed description which follows, in reference to the noted plurality of drawings by way of non-limiting examples of exemplary embodiments of the present invention, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

FIG. 1 is a schematic side view illustrating a basic cooling structure of an engine compartment employed by a work vehicle according to the present invention;

FIG. 2 is a perspective view illustrating an arrangement of an exhaust gas purification device and an exhaust passage in a rear portion of an engine hood;

FIG. 3 is a side view of a zero turn mower according to an embodiment of the present invention;

FIG. 4 is a top or plan view of the zero-turn mower;

FIG. 5 is a side view of the engine compartment;

FIG. 6 is a top or plan view of the engine compartment;

FIG. 7 is an exploded perspective view of a rear frame, a radiator, and the hood;

FIG. 8 is a front view of an area around the radiator;

FIG. 9 is a back view of an area around the exhaust gas purification device; and

FIG. 10 is a perspective view of the area around the exhaust gas purification device.

DETAILED DESCRIPTION OF THE INVENTION

The particulars shown herein are by way of example and for purposes of illustrative discussion of the embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the present invention. In this regard, no attempt is made to show structural details of the present invention in more detail than is necessary for the fundamental understanding of the present invention, the description taken with the drawings making apparent to those skilled in the art how the forms of the present invention may be embodied in practice.

Before describing a specific embodiment of a mower according to the present invention in which a diesel engine (hereafter referred to simply as an engine) is mounted, a basic structure of the present invention is described with reference to FIGS. 1 and 2. A mower is shown in FIG. 1 as an exemplary work vehicle according to the present invention. The mower shown in FIG. 1 is rendered schematically, illustrating only a vehicle frame 2 extending in a front-back direction of the vehicle, a front wheel unit, a rear wheel unit, a driver's seat 53, a mower unit 6, a transmission 4, the diesel engine (hereafter referred to simply as the engine) 3, and engine peripheral components. The engine peripheral components include a radiator 31, an air cleaner 32, a cooling fan 33, an exhaust gas purification device 36, and an exhaust passage. The exhaust passage includes an exhaust end portion 39 having a discharge opening 390 expelling exhaust gas to the vehicle exterior; an inlet-side exhaust passage 37 connecting an exhaust manifold of the engine 3 and an inlet 361 of the exhaust gas purification device 36; and an outlet-side exhaust passage 38 connecting an outlet

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362 of the exhaust gas purification device **36** and the exhaust end portion **39**. As a rule, in the present description, a front-back direction refers to a longitudinal direction (travel direction) of the mower; a lateral direction (left-right direction) refers to a width direction of the mower (i.e., a direction orthogonal to the front-back direction); and a vertical direction refers to a direction perpendicular to the ground (horizontal plane).

Next, an arrangement of components in an exhaust system, as well as a cooling structure thereof, according to the present invention are described. The engine **3** is installed in a rear portion of the vehicle frame **2**, and the cooling fan **33** is arranged forward of the engine **3**. Accordingly, cooling air generated by the cooling fan **33** flows toward the engine **3**, toward the rear of the vehicle. The exhaust gas purification device **36** is arranged rearward of the engine **3**, preferably directly behind a top portion of an engine rear wall, the exhaust gas purification device **36** including a filter (a filter generally referred to as a DPF is used) which collects particulate matter contained in the exhaust gas discharged from the engine **3**. The inlet-side exhaust passage **37** connects the exhaust manifold of the engine **3** and the inlet **361** of the exhaust gas purification device **36**. The outlet-side exhaust passage **38** connects the outlet **362** of the exhaust gas purification device **36** and the exhaust end portion **39**. The outlet-side exhaust passage **38** is configured by a first exhaust passage **381** and a second exhaust passage **382**. The first exhaust passage **381** is an exhaust circulation passage coupled to the outlet **362** of the exhaust gas purification device **36** and passing over the exhaust gas purification device **36** to reach beside a first end portion of the exhaust gas purification device **36** (in FIG. 1, a right side of the vehicle). The first exhaust passage **381** extends through a position higher than a top end of the engine **3**. The second exhaust passage **382** is an exhaust circulation passage coupled to the first exhaust passage **381** and extending in the transverse direction from beside the first end portion of the exhaust gas purification device **36**, below the exhaust gas purification device **36**, to the exhaust end portion **39**.

Specific configurations of the outlet-side exhaust passage **38** and the exhaust end portion **39** are described with reference to FIG. 2. A flow cross-sectional area of the second exhaust passage **382** is larger than the flow cross-sectional area of the first exhaust passage **381**, and a gap in the transverse direction is formed at the connection between the first exhaust passage **381** and the second exhaust passage **382** such that outside air flows into the second exhaust passage **382** together with exhaust gas from the first exhaust passage **381**. Moreover, the second exhaust passage **382** is configured by a downward portion **3821** extending downward beside the first end portion of the exhaust gas purification device **36**; a sideways portion **3822** extending horizontally in a straight line below the exhaust gas purification device **36**; and a two-dimensional bend portion **3823** coupling the downward portion **3821** and the sideways portion **3822**. In the example shown in FIG. 2, the downward portion **3821**, the sideways portion **3822**, and the two-dimensional bend portion **3823** are integrally formed. The exhaust end portion **39**, which is connected substantially coaxially to a terminal end of the sideways portion **3822**, is a cylindrical body. The outlet **390** formed on the terminal end of the exhaust end portion **39** is oriented in the transverse direction of the vehicle.

The hood **16** which delineates the engine compartment is configured by a front hood (in this example, a movable hood **16A**) covering, among other things, the radiator **31**, the cooling fan **33**, and the engine **3**; and a rear hood (in this

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example, a fixed hood **16B**) covering the exhaust gas purification device **36** and the outlet-side exhaust passage **38**. The rear hood **16B** serves as a downward deflection plate such that, after cooling air from the cooling fan **33** passes over the engine **3**, the cooling air passes behind the exhaust gas purification device **36** to arrive below the exhaust gas purification device **36**.

Next, a preferred, exemplary arrangement of the radiator **31**, the air cleaner **32**, the cooling fan **33**, and the exhaust gas purification device **36** in the engine compartment covered by the hood **16** is described. As shown in FIG. 1, the driver's seat **53** is arranged above a center region of the vehicle frame **2**, and the transmission **4** is arranged below and rearward of the driver's seat **53**. A rear wheel axle of the rear wheel unit extends in the transverse direction of the vehicle from a position rearward of the transmission **4**. The engine **3** is arranged rearward of the transmission **4**, and at a position higher (height above the ground) than a bottom end of the transmission **4**. Accordingly, on the vehicle frame **2**, the height above the ground of a bottom end portion where the engine **3** is mounted is higher than the height above the ground of the bottom end portion where the transmission **4** is mounted. This increases an allowable distance before the rear portion of the vehicle body contacts the ground when the front wheel unit is raised, and improves an ability of the vehicle body to clear obstacles.

The exhaust gas purification device **36** includes a substantially cylindrical housing having substantially the same length as the engine **3** in the transverse direction of the vehicle, and is fixed to the vehicle frame **2** at substantially the same height as the engine **3** such that a cylinder axis of the housing follows the transverse direction of the vehicle. The air cleaner **32**, which similarly includes a substantially cylindrical housing, is positioned above the engine **3** and at substantially a center position of the front-back direction length of the engine **3**, such that the cylinder axis of the housing extends along the transverse direction of the vehicle.

The radiator **31** is oriented so as to be substantially upright and is arranged in an area between the transmission **4** and the engine **3**. A bottom end of the radiator **31** is positioned directly above an input shaft **30** that is coupled to a crank shaft so as to transmit drive force from the engine **3** to the transmission **4**, and a top end of the radiator **31** projects further upward than the air cleaner **32**. As shown in FIG. 1, in the lateral view of the mower, a height direction center portion of the radiator **31** is positioned at the height of a top surface of the seat cushion **53A** of the driver's seat **53**. The height direction center portion of the radiator **31** is substantially the same height as a boundary region situated between the engine **3** and the air cleaner **32**.

The cooling fan **33** has a rotation axis **33a** (see FIGS. 4 and 5) extending from a top portion of the front wall of the engine **3** in the front-back direction of the vehicle, and takes in outside air via a cooling surface of the radiator **31**. In FIG. 1, a shroud **330** is provided between the radiator **31** and the cooling fan **33**. An air intake opening **160** is formed on a front wall of the hood **16** and the front wall faces the cooling surface of the radiator **31**. The hood **16** covers the engine **3**, the radiator **31**, the air cleaner **32**, and the exhaust gas purification device **36**. A dust net is hung across the air intake opening **160**. A bottom end of the air intake opening **160** is positioned generally at a height position of the top surface of the seat cushion **53A** of the driver's seat **53**, i.e., at a height direction center portion of the radiator **31**. A space is formed between the seat back **53B** of the driver's seat **53** and the front wall of the hood **16** where air is able to

circulate freely, and a cooling air pathway (shown by arrows in FIG. 1) is created that flows past the top half of the radiator 31, the air cleaner 32, and the exhaust gas purification device 36.

A line linking the top ends of the air cleaner 32 and the exhaust gas purification device 36 descends toward the rear, and therefore a top panel of the hood 16 is inclined in a similar shape. Cooling air running past the top half of the radiator 31 flows along the top panel of the hood 16 and obliquely downward, and is drawn downward by a deflection plate action created by the rear wall of the hood 16. The second exhaust passage 382 is exposed to the flow of cooling air, and thus is efficiently cooled.

Next, a specific embodiment of a riding mower according to the present invention is described with reference to the drawings. In the present embodiment, a structure and arrangement are employed basically as described with reference to FIGS. 1 and 2. FIG. 3 is a side view of a mower known as a zero-turn mower and is one example of a riding mower. FIG. 4 is the plan view. As illustrated in FIGS. 3 and 4, the mower is provided with a traveling vehicle body 10 which is supported on the ground by the front wheel unit, which includes the pair of left and right front wheels 11, and by the rear wheel unit, which includes the pair of rotationally driven left and right rear wheels 12. The traveling vehicle body 10 includes the vehicle frame 2 as a base member, and the mower unit 6 is suspended from the vehicle frame 2 between the front wheels 11 and the rear wheels 12 via a linking mechanism 14. An operation portion 5 is arranged in the center region of the traveling vehicle body 10 in the front-back direction of the vehicle. Therefore, in the operation portion 5, a seat support 52 is fixated on top of the vehicle frame 2 (see FIG. 1) and the driver's seat 53 is provided to a top surface of the seat support 52. The driver's seat 53 is configured by the seat cushion 53A, which holds or supports the driver's buttocks; and the seat back 53B, which holds or supports the back of the driver. Further, fenders 17 are formed on left and right side surfaces of the seat support 52. Finally, a step 50 is laid in front of the driver's seat 53.

A ROPS apparatus 13 is provided to the rear part of the operation portion 5. The engine 3 is arranged at the rear end region of the traveling vehicle body 10 and the transmission 4 is arranged in front of and slightly lower than the engine 3. The transmission 4 includes a left rear-axle transmission portion 4a and a right rear-axle transmission portion 4b. Although only the left rear-axle transmission portion 4a is depicted in FIG. 3 (using a dotted line), the right rear-axle transmission portion 4b is arranged at a position axially symmetric with the left rear-axle transmission portion 4a on the right side of the vehicle. The left rear-axle transmission portion 4a and the right rear-axle transmission portion 4b each have a built-in hydrostatic transmission (HST, an example of a continuously variable transmission), which may each be operated independently. The hydrostatic transmission can continuously vary the speed from low to high while the engine output is in normal rotation (forward) or reverse rotation (backward) and transmit the drive power of the engine to each of the left and right rear wheels 12a and 12b of the rear wheel unit. Thereby, both the left and the right rear wheels 12a and 12b may be driven in a forward direction at the same or substantially the same speed to initiate straight line forward travel, and both the left and the right rear wheels 12a and 12b may be driven in a backward direction at the same or substantially the same speed to initiate straight line backwards travel. The traveling vehicle body 10 can be made to turn in an arbitrary direction by

ensuring the speeds of the left and the right rear wheels 12a and 12b are different from each other; for example, operating one of the left or right rear wheels 12a or 12b at a low speed near zero and operating the other of the rear wheels 12a and 12b forward or backward at a high speed can cause the traveling vehicle body 10 to make a small turn. Additionally, driving the left and the right rear wheels 12a and 12b in mutually opposite directions can cause the traveling vehicle body 10 to perform a spinning turn about a turning center that is substantially the center portion between the left and right rear wheels 12a and 12b. The front wheel unit is configured by a left-right pair of caster wheels, and can change orientation freely about a vertical axis center. Thus, the front wheel unit is capable of correcting the orientation of the traveling vehicle in accordance with the travel direction, which is defined by how the left and right rear wheels 12 are driven.

A speed change operation on the transmission 4, and in particular a speed change operation on the left rear-axle transmission portion 4a and the right rear-axle transmission portion 4b, is carried out using a pair of left and right speed change levers 51 arranged on both sides of the driver's seat 53. When the speed change levers 51 are held at a front-back direction neutral position, the continuously variable transmission is in a neutral stop. When the speed change levers 51 are moved forward or rearward from the neutral position, a forward speed change or a backward speed change, respectively, occurs.

As shown in FIG. 4, the vehicle frame 2 of the traveling vehicle body 10 is configured by a front frame 21 that is broad in width and a rear frame 22 that is narrow in width. The front frame 21 and the rear frame 22 are configured by a left-right pair of vertical beams extending in the front-back direction of the vehicle, and by a crossbeam linking the vertical beams. The width of the front frame 21 (space between the left and right vertical beams) is greater than that of the rear frame 22, and a front portion of the rear frame 22 fits inside a rear portion of the front frame 21 as seen in a plan or top view. The front portion of the rear frame 22 is coupled to the rear portion of the front frame 21 by a coupling member (not shown in the drawings). A box-shaped rear end frame 220 (see FIGS. 3, 5 and 6) is fixated to the rear end of the rear frame 22 so as to create a space to the rear of the engine 3.

The engine 3 is installed in the middle of the rear frame 22 and is generally isolated from vibration. An input shaft 30 (seen most clearly in FIG. 1) extends substantially horizontally, coaxially with an extended portion of a crank shaft protruding forward from a lower portion of the front wall of the engine 3, the input shaft 30 transmitting drive power from the engine to the transmission 4. In order to permit the greatest possible lifting of the left and right front wheels 11a and 11b, the height of the rear portion of the traveling vehicle body 10 above the ground must be raised. Therefore, the engine 3 is arranged in a higher position off the ground than the transmission 4. A PTO shaft 41, which transmits drive power to the mower unit 6, projects forward from the front wall of the transmission case 40 of the transmission 4. The height of the transmission 4 above the ground is low so as to not increase an angle of inclination of a PTO intermediate shaft 62, which connects the PTO shaft 41 and the PTO input 61 of the mower unit 6.

The cooling fan 33 is arranged forward of the engine 3 such that a top end of the cooling fan 33 is at substantially the same height as the top end of the engine 3. The cooling fan 33 includes a rotation shaft 33a provided to a top portion of the front wall of the engine 3, with the rotation shaft 33a

(see FIG. 5) extending in the front-back direction and transmitting drive power from the extended portion of the crank shaft with a belt transmission. The radiator 31 is arranged forward of the cooling fan 33. The radiator 31 is provided in an upright posture (i.e., extending in a perpendicular direction) such that the cooling surface of the radiator 31 faces a rotation trajectory plane of the cooling fan 33. A bottom end of the radiator 31 is adjacent to the input shaft 30, and the height of the bottom end is located at substantially a middle height between the top end of the transmission 4 and the input shaft 30. A shroud 330 is located between the cooling fan 33 and the radiator 31. As shown in FIGS. 6 and 7, left and right side portions of the shroud 330 extend up to side panels of the hood 16 and act as a dividing wall separating the engine compartment into an engine space and a radiator space.

As shown in FIG. 3, the hood 16 delineating the engine compartment is configured by a fixed hood 16B and a movable hood 16A, with the fixed hood 16B functioning as the rear hood fixed to the rear end frame 220. The movable hood 16A functions as a front hood opening and closing around an open-close axis center Pb, which extends horizontally in the transverse direction of the vehicle. As shown in FIG. 7, the movable hood 16A is open on a rear surface, and is configured by a left-right pair of side panels 161 forming side surfaces. A top panel 162 forms a top surface; and a front panel 163 forms a front surface. A plurality of openings 165 are provided across the entire front panel 163, as well as on a front end region of the side panels 161 and the top panel 162. One or more dust nets are mounted to or on the openings 165. A rectangular recessed portion 164 is formed on a lower half of the front side of the side panels 161, and a dust net-covered opening 165 is also arranged on a side wall (side surface or top surface) of the recessed portion 164. Accordingly, as shown in FIG. 8, the cooling fan 33 can take in air through the top surface and side surfaces of the movable hood 16A to create a cooling airflow.

The front panel 163 of the movable hood 16A is bent in or at a lateral direction crease. When the movable hood 16A is in a closed state, the lower half of the front panel 163 forms a perpendicular surface, whereas the upper half of the front panel 163 forms an inclined surface inclining upward and toward the rear. As clearly shown in FIG. 5, an airflow space is formed between the front panel 163 of the closed movable hood 16A and the occupied seat back 53B, and essentially, a horizontal cross-sectional area of the airflow space progressively increases further upward. By driving the cooling fan 33, the cooling airflow taken in through the airflow space passes over the radiator 31 and flows into the area around the engine 3. The cooling airflow strikes the front wall and flows into a space above the engine 3.

A dust cover 311 is also mounted to the front surface of the radiator 31. A material that is finer than the dust cover arranged on or over the openings 165 is used as the mesh of the dust cover 311. The dust cover 311 is bent such that a top end thereof acts as a handle 3111. The dust cover 311 is mounted to the radiator 31 so as to be capable of being pulled upward. Accordingly, when the dust cover 311 is to be removed, a hand reaches in from above, grips the handle 3111, and pulls the dust cover 311 upward. The handle 3111 is not bent at a 90° angle, but rather is bent at a somewhat gentler angle, such as 70°, to facilitate gripping.

The cylindrical air cleaner 32 lies horizontally (such that a cylinder axis lies along the transverse direction of the vehicle) above the engine 3. An inflow pipe 331 of the air cleaner 32 extends upward at a slight angle from the air

cleaner 32 and runs through a top portion of the shroud 330. An intake opening 320 of the inflow pipe 331 reaches a top end of the radiator 31 in the radiator space. An outflow pipe 332 of the air cleaner 32 extends downward, bending in a “U” shape, and connects to an intake manifold of the engine 3. The height of the bottom end of the radiator 31 is substantially the height of the crank shaft, and the height of the top end of the radiator 31 is substantially the height of the intake opening 320 of the air cleaner 32. In other words, the radiator 31 extends so as to project upward through a region between the driver's seat 53 and the air cleaner 32, higher than the top end of the air cleaner 32.

As shown in FIGS. 5 and 6, the exhaust gas purification device 36, which has substantially a cylindrical shape, is arranged to the rear of the engine 3 and lying horizontally (such that the cylinder axis lies along the transverse direction of the vehicle) substantially at the height of the engine 3. A filter called a DPF is installed in the exhaust gas purification device 36, with the DPF collecting particulate matter contained in the exhaust gas discharged from the engine 3. The exhaust gas purification device 36 is interposed in the exhaust pipe system of the engine 3. The exhaust pipe system is configured by the exhaust end portion 39 forming a discharge opening 390 expelling exhaust gas to the vehicle exterior; with the inlet-side exhaust passage 37 connecting the exhaust manifold of the engine 3 and an inlet 361 of the exhaust gas purification device 36; and the outlet-side exhaust passage 38 connecting an outlet 362 of the exhaust gas purification device 36 and the exhaust end portion 39.

As clearly shown in FIGS. 9 and 10, the outlet-side exhaust passage 38 is configured by the first exhaust passage 381 and the second exhaust passage 382. A projecting end of the first exhaust passage 381 is coupled to the outlet 362 of the exhaust gas purification device 36. The first exhaust passage 381 rises from the outlet 362 at a forward angle above the exhaust gas purification device 36, then bends into a U-turn shape, a terminal end of which extends to be beside the right-side end of the exhaust gas purification device 36. A projecting end of the second exhaust passage 382 is coupled to the first exhaust passage 381. In the present embodiment, the coupling of the first exhaust passage 381 to the second exhaust passage 382 is a coupled state where the terminal end of the first exhaust passage 381, which is formed to have a diameter greater than the first exhaust passage 381, is either inserted into the projecting end of the second exhaust passage 382, or is positioned substantially coplanar with or spaced slightly apart from the projecting end of the second exhaust passage 382, thereby creating a gap between the two members through which the cooling airflow enters. The second exhaust passage 382 is configured by the downward portion 3821, which has substantially a straight line shape and runs beside the right-side end portion of the exhaust gas purification device 36; with the sideways portion 3822 extending in the transverse direction of the vehicle below the exhaust gas purification device 36 to reach the exhaust end portion 39; and the 90° bend portion 3823 coupling the downward portion 3821 and the sideways portion 3822. The bend portion 3823 is formed as a two-dimensional bent path, the center axis of which is positioned on a two-dimensional plane. The coupling of the second exhaust passage 382 to the exhaust end portion 39 is also a coupled state where the terminal end of the second exhaust passage 382 is either inserted into the exhaust end portion 39, which is formed to have a diameter greater than the second exhaust passage 382, or is positioned substantially coplanar with or spaced slightly apart from the exhaust end

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portion 39, thereby creating a gap between the two members through which the cooling airflow enters.

As clearly shown in FIG. 5, a sectional face of the interior surface of the fixed hood 16B, as seen in a side view, has a shape that follows a rearward, side view outline of the exhaust gas purification device 36, the first exhaust passage 381, and the second exhaust passage 382. In other words, the interior surface of the fixed hood 16B acts as a downward deflection plate oriented such that the cooling air that has passed through the air cleaner 32 moves from the first exhaust passage 381 behind the exhaust gas purification device 36 to arrive below the exhaust gas purification device 36. In the present embodiment, a first deflection plate 160a causes the cooling air to flow downward and rearward and is arranged in the interior of the top portion of the fixed hood 16B, and a second deflection plate 160b causes the cooling air to flow downward and forward and is arranged in the interior of the bottom portion of the fixed hood 16B.

As shown in FIGS. 3 and 7, the ROPS 13 includes a left-right pair of supporting columns 13a and a horizontal member 13b connecting the supporting columns 13a. The supporting columns 13a can pivot to bend in the middle. A leg 131, which is the lower half of the supporting column 13a, curves inward at substantially the same height position as the top end of the rear frame 22, and extends until reaching the rear end of the front frame 21. The rear end of the front frame 21 and the leg 131 of the ROPS 13 are coupled via a coupling bracket. A straight-line support column 132, which is the upper half of the support column 13a, is coupled to the leg 131 via a pivoting coupler so as to be capable of pivoting between a vertical posture and a sideways (or downward) posture.

The step 50 is mounted to the front frame 21 in a foot area of the driver's seat 53. The fenders 17 are provided on the left and right of the driver's seat 53, and fuel tanks 18 are provided below each of the fenders 17. A brake pedal 191 is arranged close to the center of a front region of the step 50. A brake lock pedal 192 for parking, which holds the brake pedal 191 in a depressed position, is provided beside the brake pedal 191.

Other Embodiments

(1) In the specific embodiment described above, a mower referred to as a zero-turn mower is disclosed as the work vehicle. However, the present invention can also be applied to other types of mowers such as a front mower, in which the mower unit 6 is mounted forward of the front wheels 11. The present invention can also be applied to a work vehicle other than a mower, such as a tractor or snowplow.

(2) In the specific embodiment described above, the hood 16 was divided into a front hood (the movable hood 16A) and a rear hood (the fixed hood 16B). Instead, both sections may be movable hoods, or the hood 16 may be configured as an undivided, single member or hood.

(3) In the specific embodiment described above, the first deflection plate 160a and the second deflection plate 160b were formed on or made part of the interior of the top portion of the fixed hood 16B. However, the deflection plates may be formed either as components of the fixed hood 16B, or as separate components. In addition, instead of two deflection plates, a configuration may be employed which creates or deflects cooling air with a single component, or with three or more components.

The present invention can be applied to a work vehicle having a diesel engine installed in a rear portion of a vehicle frame.

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It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to exemplary embodiments, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the present invention has been described herein with reference to particular structures, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

The present invention is not limited to the above described embodiments, and various variations and modifications may be possible without departing from the scope of the present invention.

What is claimed is:

1. A work vehicle comprising:

a diesel engine mounted in a rear portion of a vehicle frame;

a cooling fan arranged forward of the diesel engine;

an exhaust gas purification device configured to filter particulate matter contained in exhaust gas discharged from the diesel engine;

an exhaust discharge opening expelling the exhaust gas to a vehicle exterior;

an inlet-side exhaust passage conveying exhaust gas from an exhaust manifold of the diesel engine to an inlet of the exhaust gas purification device;

an outlet-side exhaust passage conveying exhaust gas from an outlet of the exhaust gas purification device to the exhaust discharge opening;

a first portion of the outlet-side exhaust passage extending from the outlet of the exhaust gas purification device to a first end portion of the exhaust gas purification device; and

a second portion of the outlet-side exhaust passage arranged downstream of the first portion and being each of:

oriented along a transverse direction of the work vehicle; and

arranged below the exhaust gas purification device.

2. The work vehicle according to claim 1, wherein the exhaust gas purification device comprises a filter configured to collecting particulate matter.

3. The work vehicle according to claim 1, wherein the first portion has a portion located at a position higher than a top end of the diesel engine.

4. The work vehicle according to claim 1, wherein the second portion has a larger flow cross-sectional than the first portion.

5. The work vehicle according to claim 4, further comprising a gap arranged between an downstream end of the first portion and an upstream end of the second portion.

6. The work vehicle according to claim 1, further comprising a gap arranged between an downstream end of the first portion and an upstream end of the second portion.

7. The work vehicle according to claim 1, further comprising a gap arranged adjacent the first end portion of the exhaust gas purification device, said gap being located between an downstream end of the first portion and an upstream end of the second portion.

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8. The work vehicle according to claim 1, wherein the second portion further comprises a generally up and down oriented first section arranged upstream of a section oriented along the transverse direction of the work vehicle.

9. The work vehicle according to claim 8, wherein the second portion further comprises an elbow section disposed between the generally up and down oriented first section and the section oriented along the transverse direction of the work vehicle.

10. The work vehicle according to claim 1, wherein the exhaust discharge opening is oriented in the transverse direction of the work vehicle.

11. The work vehicle according to claim 1, further comprising an engine hood configured to cover at least one of:
a cooling fan;
the diesel engine;
the inlet-side exhaust passage;
the exhaust gas purification device; and
the outlet-side exhaust passage.

12. The work vehicle according to claim 11, wherein the engine hood comprises a first hood configured to cover:
the cooling fan;
the diesel engine; and
the inlet-side exhaust passage.

13. The work vehicle according to claim 11, wherein the engine hood comprises a second hood configured to cover:
the exhaust gas purification device; and
the outlet-side exhaust passage.

14. The work vehicle according to claim 13, wherein the second hood is a rear hood and the hood is configured to deflect or direct cooling air from the cooling fan, over the diesel engine, behind the exhaust gas purification device, and to a position below the exhaust gas purification device.

15. The work vehicle according to claim 1, further comprising a radiator positioned forward of the diesel engine and being vertically arranged such that an imaginary line passing through a center of the radiator passes through a region located above the diesel engine and below an air cleaner positioned above the diesel engine.

16. A work vehicle comprising:
a diesel engine mounted in a rear portion of a vehicle frame;
a cooling fan arranged forward of the diesel engine;
an exhaust gas purification device configured to filter particulate matter contained in exhaust gas discharged from the diesel engine;
an exhaust discharge opening expelling the exhaust gas to a vehicle exterior;

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an inlet exhaust pipe conveying exhaust gas from an exhaust manifold of the diesel engine to an inlet of the exhaust gas purification device;

a first pipe section extending from an outlet of the exhaust gas purification device to one of two opposite ends of the exhaust gas purification device; and

a second pipe section downstream of the first pipe section, wherein the second pipe section comprises:

an upstream end coupled to a downstream end of the first pipe section;

a main section oriented along a transverse direction of the work vehicle and arranged below the exhaust gas purification device; and

a downstream end extending to the exhaust discharge opening.

17. The work vehicle according to claim 16, wherein the exhaust gas purification device is generally cylindrical.

18. The work vehicle according to claim 16, wherein the first pipe section is generally U-shaped.

19. The work vehicle according to claim 16, wherein the first pipe section is generally L-shaped.

20. A work vehicle comprising:

a diesel engine mounted in a rear portion of a vehicle frame;

a cooling fan arranged forward of the diesel engine;

an exhaust gas purification device configured to filter particulate matter contained in exhaust gas discharged from the diesel engine;

an exhaust discharge opening expelling the exhaust gas to a vehicle exterior;

an inlet exhaust pipe conveying exhaust gas from an exhaust manifold of the diesel engine to an inlet of the exhaust gas purification device;

a first pipe section having one end coupled to an outlet of the exhaust gas purification device and another end located a transverse side of the exhaust gas purification device;

a second pipe section arranged downstream of the first pipe section and having a larger cross-section than the first pipe section; and

a gap arranged between the first pipe section and the pipe section,

wherein the second pipe section comprises:

a main section oriented generally along a transverse direction of the work vehicle and arranged below the exhaust gas purification device; and

a downstream end extending to the exhaust discharge opening.

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